JIS Z 8812 (1987) (English): Measuring methods of eye-hazardous ultraviolet radiation

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JAPANESE INDUSTRIAL STANDARD

Measuring Methods of Eye-hazardous Ultraviolet Radiation

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JAPANESE INDUSTRIAL STANDARD J I S

Measuring Methods of Eye-hazardous Ultraviolet Radiation Z 8812-1987

1. Scope

This Japanese Industrial Standard specifies the physical measuring methods of eye-hazardous irradiance of eye-hazardous ultraviolet radiation relative to human eyes in general artificial light and natural light, hereinafter referred to as the "eye-hazardous ultraviolet radiation". However, except the measurement of direct radiation of laser.

2. Definitions

For the purposes of this Standard main terms are in accordance with JIS Z 8113, and for others following definitions apply:

(1) eye-hazardous ultraviolet radiation The ultraviolet radiation givening rapid hazard corner or conjunctive of human eye. The wavelength range is 200 to 315 nm, and the hazardous spectral action characteristics are as shown in Fig. 1.

Remark: Previously it is called eye-hazardous ultraviolet rays.

(2) TLV The abbreviation of Threshold Limit Values. Concerning the ultraviolet radiation of 200 to 315 nm in wavelength, the quantity which the worker under its illuminating may receive the exposure repeatedly without receiving harmful affects, and the value indicated by J/m^2 for each wavelength.

Further, this TLV shall not be considered to be one line to divide the safety level and dangerous level.

(3) relative spectral eye-hazardous action The inverse number of TLV, and the value expressed by standardizing the maximum value (the value of 270 nm) as 1.

(4) eye-hazardous radiant flux The effective radiant flux of eye-hazardous ultraviolet radiation. It is obtained by the integrated style of the spectral radiant flux of radiation source multiplied by the value of relative spectral eye-hazardous action and its strength is expressed by eye-hazardous watt [W (haz)].

(5) eye-hazardous irradiance The density of eye-hazardous radiant flux per unit area of plane of incidence. The unit shall be W/m^2 (haz) or $\mu W/m^2$ (haz) or the like.

Applicable Standards:

JIS C 7604-High Pressure Mercury Vapour Lamps

JIS C 7605-Low Pressure Mercury Germicidal Discharge Lamps

JIS Z 8113-Glossary of Lighting Terms

(6) normal irradiance The irradiance on a plane perpendicular to advancing direction of radiation.

(7) horizontal-plane irradiance The irradiance on a horizontal plane.

(8) vertical-plane irradiance The irradiance on a vertical plane.

3. TLV

TLV and relative spectral eye-hazardous action shall be as shown in Table 1 and Fig. 1.

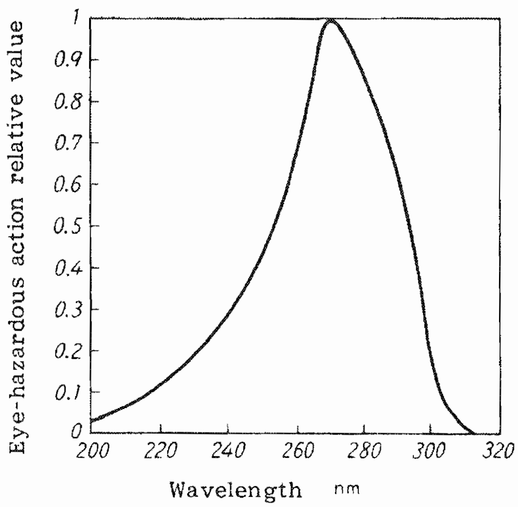
Table 1. TLV and Relative Spectral Eye-Hazardous Action

Wavelength nm	TLV J/m^2	Relative spectral eye-hazardous action
200	1000	0.03
210	400	0.075
220	250	0.12
230	160	0.19
240	100	0.30
250	70	0.43
254	60	0.5
260	46	0.65
270	30	1.0
280	34	0.88
290	47	0.64
300	100	0.30
305	500	0.06
310	2000	0.015
315	10000	0.003

Remark: TLV is the recommended value of ACGIH (American Conference of Governmental Industrial Hygienists) and this value is the allowable amount in the case where receiving exposure taking one day (8 h) as one period.

ACGIH: See Threshold Limit Values for Physical Agents in the Work Environment Adopted by ACGIH with Intended Changes for 1985-1986.

Fig. 1. Relative Spectral Eye-Hazardous Action Curve



4. Measuring Instrument of Eye-hazardous Ultraviolet Radiation

For measurement of eye-hazardous ultraviolet radiation, a radiation-illumination photometer for eye-hazardous ultraviolet radiation, hereinafter referred to as the "radiation-illumination photometer", shall be used. The spectral response characteristics of light receptor shall be as approximate as possible and the minimum detecting capability should preferably be superior to 100 μW/m² (haz). The angular characteristics of incident light oblique to light receptor from the radiation source having broading should preferably be proportional to cosine (cosine law) of the angle included by normal direction of light receiving plane and the incident light. If the deviation from the cosine law is remarkable, the measurement values shall be corrected according to the method specified in 5.2.2.

Remark: As the method for approximating the spectral response characteristics of light receptor to Fig. 1, there is the following. The vacuum phototube (caesium-tellurium cathod) having responsibility in the wavelength range of 180 to 320 nm and the zone filter of about 270 nm in maximum transmission wavelength and of about 40 nm in half-width (multilayer diaphragm type and the like) are combined.

5. Measuring Methods of Eye-hazardous Irradiance

5.1 Classification of Irradiance The eye-hazardous irradiance shall be classified according to the measuring conditions into normal irradiance, horizontal plane irradiance and vertical plane irradiance.

5.2 Measurement of Normal Irradiance

5.2.1 Installation Method of Radiation Illumination Photometer Place the light receiving surface or light receiving window of radiation illumination photometer at a place to measure eye-hazardous ultraviolet radiation, and let be opposite to the middle part of eye-hazardous ultraviolet radiation source to measure.

5.2.2 Correction of Deviation from Cosine Law The angular characteristics of incident light oblique to light receptor should preferably be in accordance with the cosine law in the angle of light receptor viewing-in the objective radiation source.

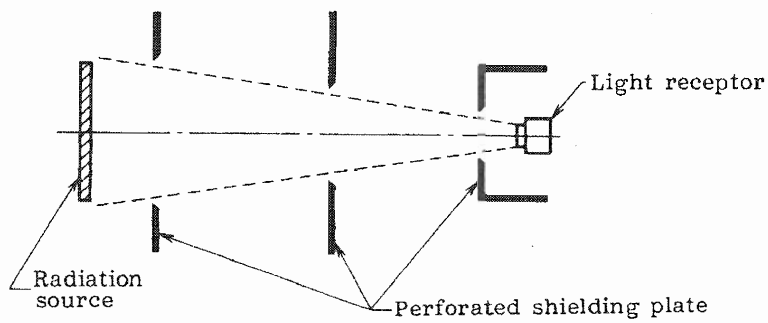
Further, when at the required position in the angle viewing-in the radiation source, the angular characteristics of incident light oblique to light receptor are insufficient, the distance between the radiation source and the light receiving surface is so widened that the angle viewing-in the radiation source becomes in the range where the cosine law is satisfied to measure the irradiance, and from the value, the irradiance at the required position shall be calculated (see Appendix. Calculation Methods for Irradiance).

When the objective radiation source has complex size and shape or two or more sources exist, for the light receptor at the measuring position in the incident angle viewing in these radiation angle, the angular characteristics of incident light oblique to the light receptor should preferably satisfy the cosine law. However in case where the cosine law is not satisfied in the overall incident angle range of light receptor, in the range of angle satisfying the cosine law, each one part or each unit separately is measured to be obtained by calculation.

5.2.3 Use of Perforated Shielding Plate As in the case of measuring the eye-hazardous ultraviolet radiation output of radiation source, when making only direct radiant flux coming from the objective radiation source the measuring object, a suitable perforated shielding plate or the shielding cylinder having the equivalent effect shall be so placed between the objective radiation source and the light receptor that the radiation coming from other radiation source and the scattering radiation from the environment are not incident in light receptor. The perforated shielding plates of plural sheets are used generally, and it is desirable that the shape of hole approximates the normal projection of radiation source viewed from the position of light receptor, but it may be round shape.

The dimensions of hole, outside shape dimensions, and arrangement of each perforated shielding plate shall be so selected that the visual field of light receptor is limited to the objective radiation source (see Fig. 2). The surface of perforated shielding plate shall be finished with black delustering (for example, black velvet sticking) which is extremely low in reflectance of ultraviolet radiation and visible radiation, and the edge of hole, be blade state. In case where the use of perforated shielding plate or shielding cylinder is difficult, after measuring with including scattering radiant flux from the environment, a black-delustering finished shielding plate (for example, that of approximately same size as that of this radiation source) is inserted in the optical path at a position near the radiation source to measure only scattering radiant flux by the method interrupting the direct radiant flux toward the light receptor and the direct radiant flux shall be obtained by subtracting the latter from the former.

Fig. 2. Using Method of Perforated Shielding Plate



5.3 Measurement of Horizontal Plane or Vertical Plane Irradiance

5.3.1 Directly Measuring Method For measuring the horizontal plane or vertical plane irradiance, the light receiving window or light receiving surface of radiation illumination photometer is holed horizontally or vertically at the measuring place, and these shall be measured according to the method specified for each measuring instrument. In this case, the angular characteristics of incident light oblique to the receptor should preferably satisfy the cosine law.

Further, in case where the cosine law is not satisfied, it shall be in accordance with 5.2.2, as appropriate.

5.3.2 Method for Obtaining by Calculation from Normal Irradiance The calculation shall be carried out based on the value of normal irradiance measured according to the method of 5.2 (see Appendix. Calculation Methods for Irradiance).

5.4 Measurement of Variable Irradiance For measurement of irradiance which varies irregularly in time such as eye-hazardous ultraviolet radiation irradiated from arc at welding and the like, supply the output of radiation illumination photometer to recording device to self-record the timely transfer of irradiance, obtain the average [W/m^2 (haz)] in a definite period of time or measure the eye-hazardous ultraviolet radiant quantities [$W \cdot s/m^2$ (haz)] by means of a integrating radiation illumination-photometer for eye-hazardous ultraviolet radiation and thereafter calculate the average value [W/m^2 (haz)] in that period of time.

In the case where inevitably a radiation illumination-photometer for eye-hazardous ultraviolet radiation of direct reading type is used, carry out the measurement not less than 5 times in unit measuring time, and obtain the average.

In the case of obtaining the instantaneous maximum value of irradiance, us the measuring instrument of small time constant (for example, of ms degree).

In case of flash difficult in reading out the maximum value, measure the flash eye-hazardous ultraviolet radiant quantities [$W \cdot s/m^2$ (haz)] by means of an integrating radiation illumination-photometer for eye-hazardous ultraviolet radiation.

6. Calibration of Measuring Instrument

The calibration radiation source to be used for calibration of radiation illumination-photometer shall be the fluorescent lamp for hygienic rays other than the germicidal lamps specified in JIS C 7605 of which output of eye-hazardous ultraviolet radiation is preliminarily evaluated.

Out of these, the germicidal lamp shall be used for calibration in the case of measuring ultraviolet radiation of 253.7 nm in wavelength, and the fluorescent lamp for hygienic rays, for that of 280 to 315 nm in wavelength.

For confirming that the ultraviolet radiation of long wavelength not less than 365 nm is not sensitized, when measuring with the short wavelength ultraviolet radiation shut off filter (for example, vV-35) applied to light receptor at a distance of 1 m from the high pressure mercury vapour lamp H 100 specified in JIS C 7604, the indication shall be almost zero. The detection element such as phototube and the filter may have ageing, and therefore the calibration of radiation illumination-photometer shall be carried out at least once per year.

Remark: The spectral responsibility characteristics of radiation illumination-photometer should preferably be concident with relative spectral eye-hazardous action of Fig. 1, but actually more-or-less deviation is inevitable. In order to make measurement error caused by this deviation little, for example, the following using method shall be carried out.

(1) In the case where the germicidal ultraviolet radiation is problem, the measurement shall be carried out by using the calibrated value by germicidal lamp evaluated by eye-hazardous radiant flux.

(2) In the case where the ultraviolet radiation of wide wavelength range such as arc at arc welding, the calibrated value by fluorescent lamp for hygienic rays evaluated by eye-hazardous radiant flux shall be used.

(3) In the other general cases, the calibrated value by fluorescent lamp for hygienic rays evaluated by eye-hazardous radiant flux shall be used to measure.

7. Marking of Measurement Results

The measured values shall, as a rule, be marked with eye-hazardous ultraviolet irradiance and appended with the following items:

(1) Type of radiation source and its size

(2) Distance (m) between the radiation source and the light receptor and incident angle(°). However, in the case of normal irradiance, the description of incident angle is omitted.

(3) Classification of measuring irradiance

(4) Type of radiation illumination-photometer used for measurement

The description of measured values shall be carried out in this sequence and on the items of (2) to (4), the symbol of Table 2 shall be used.

Table 2. Symbols for Appending Items

Item	Classification	Symbol
Distance between radiation source and receptor and incident angle	Distance 1 m (example) Incident angle 30° (example)	1 m (30°)
Classification of measuring irradiances	Normal irradiance	[N]
	Horizontal plane irradiance	[H]
	Vertical plane irradiance	[V]
Classification of radiation illumination-photometer	Radiation illumination-photometer for eye-hazardous ultraviolet radiation (direct reading type)	HM
	Integrating radiation illumination-photometer for eye-hazardous ultraviolet radiation	HIM

The description of measurement results shall, as a rule, be in accordance with the following example.

Example 1 In the case where the vertical plane irradiance for eye-hazardous ultraviolet radiation of shielded metal arc welding 150 A has been measured at a distance of 0.5 m and at incident angle of 20° by means of a radiation illumination-photometer for eye-hazardous ultraviolet radiation.

0.57 W/m² (haz) Shielded metal arc welding 150 A 0.5m (20°)
[V] HM (o o o manufacture)

Example 2 In the case where the horizontal plane irradiance for eye-hazardous ultraviolet of 15 watt germicidal lamp has been measured at a distance of 1 m and at incident angle of 10° by means of a radiation illumination-photometer for eye-hazardous ultraviolet radiation.

0.15 W/m² (haz) Germicidal lamp 15 watt 1 m (10°)
[H] HM (◇◇◇ manufacture)

Appendix. Calculation Methods for Irrdiance

1. In the Case of Point Radiation Source

Even a radiation source has a certain size, when the length or diameter of the radiation source is not more than 1/10 of the distance between the point to obtain irradiance and the radiation source, it shall be considered to be point radiation source. When considered that the radiation source is completely scattering, the irradiance H (W/m^2) of the point at a distance D (m) from the point radiation source is as follows:

$$H=\frac{NA}{D^2}\ (W/m^2)$$

where N : radiance of radiation source [$W/(sr\cdot m^2)$]

A : area of radiation source (m^2)

This is called inverse square law of illuminance, and when by utilizing this relation the radiation strength in the direction from the point radiation source S to SP in Appendix Fig. 1 is taken as J_θ (W/sr), the irradiance at P point becomes as follows:

Normal irradiance $$H_n=\frac{J_\theta}{SP^2}$$

Horizontal plane irradiance $$H_h=\frac{J_\theta \cos\theta}{SP^2}$$

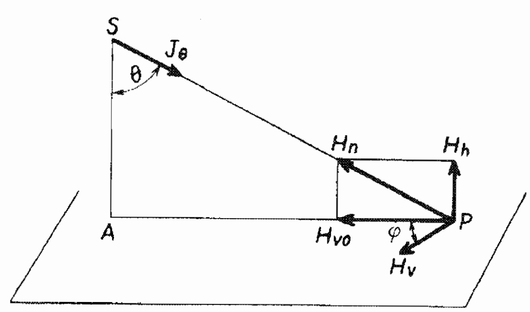
Vertical plane irradiance $$H_v=\frac{J_\theta \sin\theta\cdot\cos\varphi}{SP^2}$$

Vertical plane irradiance (when φ = 0) $$H_{v0}=\frac{J_\theta \sin\theta}{SP^2}$$

where θ : elevation angle

φ : azimuth

Appendix Fig. 1



2. In the Case of Complete Scattering Linear Radiation Source

In Appendix Fig. 2, S is assumed that it is a circular column radiation source placed horizontally, and its radius is extremely small in comparison with the length L (m).

When the radiance is taken as N [W/(sr·m^2)], and the diameter D (m), the strength of radiation per unit length J is as follows:

$$J = N \cdot D(\mathrm{W/sr})$$

When P point is taken as that it exists on a plane intersecting perpendicularly with S at an end A on the axis of linear radiation source S, the irradiance at P point by S is as follows:

Normal irradiance

$$H_n = \frac{J}{21}(\alpha + \sin\alpha \cdot \cos\alpha)$$
$$= \frac{J}{2}\left\{\frac{L}{h^2+d^2+L^2} + \frac{1}{\sqrt{h^2+d^2}}\tan^{-1}\frac{L}{\sqrt{h^2+d^2}}\right\}$$

Horizontal plane irradiance

$$H_z = H_n \sin\delta$$
$$= \frac{J}{2}\frac{h}{\sqrt{h^2+d^2}}\left\{\frac{L}{h^2+d^2+L^2} + \frac{1}{\sqrt{h^2+d^2}}\tan^{-1}\frac{L}{\sqrt{h^2+d^2}}\right\}$$

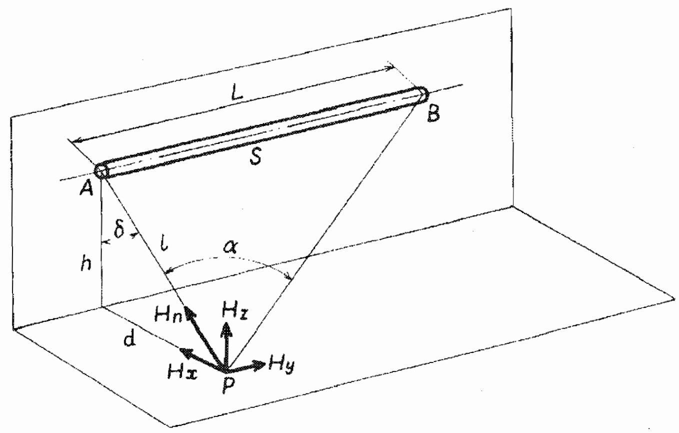
Vertical plane irradiance

$$H_x = H_n \sin\delta$$
$$= \frac{J}{2}\frac{d}{\sqrt{h^2+d^2}}\left\{\frac{L}{h^2+d^2+L^2} + \frac{1}{\sqrt{h^2+d^2}}\tan^{-1}\frac{L}{\sqrt{h^2+d^2}}\right\}$$
$$H_y = \frac{J}{2}\cdot\frac{L_2}{h_2+d_2+L_2}$$

where

- l : length of perpendicular from point P to S (m)
- h : height of S relative to the horizontal plane containing point P (m)
- d : distance from point P to vertical plane containing central line AB of S (m)
- α : viewing angle of AB at point P
- δ : angle including AP and vertical line

Appendix Fig. 2



In the case where the position of point P relative to linear radiation source S is as shown in Appendix Fig. 3 (a) and (b), the point where the plane containing point P intersects perpendicularly with the axis AB of S is taken as C. When the linear radiation source is divided by C, the length of CA is taken as L_1, the length of CB, as L_2, and to the respective amounts suffix 1 or 2 is appended, the following formulae are obtained:

(a) $H_z = H_{z1} - H_{z2}$

$H_x = H_{x1} - H_{x2}$

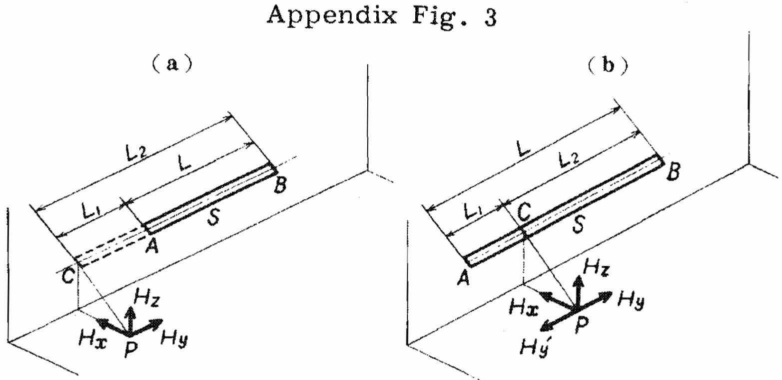
$H_y = H_{y1} - H_{y2}$

(b) $H_z = H_{z1} + H_{z2}$

$H_x = H_{x1} + H_{x2}$

$H_y = H_{y1}$, $H'_y = H_{y2}$

Appendix Fig. 3



In the case of completely scattering radiation source other than this, see "Lighting handbook" (Corporate Juridical Person Illumination Institute editing).

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